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variations appear to be quite irregular, they are mostly of small range, and at least one of them has been called "nova-like" by the discoverer.

In conclusion it is interesting to notice that at least two objects appear to be entitled to the name new star in a literal sense. They are stars which have increased in brightness from the unknown, and do not fade away. One of these stars, RT *Serpentis*, I discussed in an earlier volume of these PUBLICATIONS[9]; it has been of magnitude 11 for the last seven years, first appearing in 1909 as a star of magnitude 14. The other is 27. 1920, which, according to Wolf[10], appeared in 1908 and had reached the eleventh magnitude in 1920. Eventually these two stars may fade away; or they may be stars slowly emerging from behind obscuring clouds, rather than objects newly born. But their history as now known entitles them to the name new star without quotation marks or qualifications.

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[9] *Publ. A. S. P.*, **31**, 226, 1919. Cf. also *Harv. Bull.* 753, May, 1921.
[10] *A. N.* **212**, 75, 1920.

## THE VARIATION OF LONGITUDE*

By R. H. Tucker.

The variation of astronomical longitudes is more difficult to detect than the corresponding and simultaneous variation of latitudes. The only obvious direct test is that of the variation in the readings of the level of a meridian circle. The results of the zenith telescope observations for latitude may be considered to be practically the observation of the changes in the delicate level attached to the instrument. These changes are due to the variation in the inclination, north and south, of the line representing the direction of the gravitational attraction of the Earth. Observations of latitude with a meridian circle record the same variations of the vertical.

Level observations in meridian circle work measure primarily the variations in level of the supports of the instrument. They include also the effects of any variation, east and west, of the line representing the direction of gravity. If an instrument could be constructed, the supports of which would have no variations in level, the test for variation of longitude would be simple and direct. But we are not limited by quite so rigid and impossible a condition of instrumental equipment. If actual variations in the level of the supports follow some definite law of change, either progressive or periodic in character, or both combined, these effects can be computed, and can be allowed for in making a test of further periodic variations in the residual changes of level readings. The exceptionally consistent performance of the Lick Observatory meridian circle, with respect to variations in level, has made possible the computation of periodic terms that appear to be due to the variation of longitude at this station.

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The level corrections of over two thousand nights, in the interval 1893 to 1921, have been tabulated. The instrument was twice adjusted in level, during this interval. The only observations rejected were those of two nights immediately following one of the adjustments, when the supports had evidently not taken up a permanent position, following the tension of the new strains.

A first approximation was made by adopting a mean value for the intervals between adjustments. The use of a mean value for an interval of ten years is certainly a severe test of the performance of an instrument. The results of these first approximations do not differ widely from the final figures of a more precise computation. Following the derivation of the most pronounced periodic term, with a period of one year, the original corrections were divided into yearly groups, for the computation of residual variations. There are progressive changes in the level of the instrument, especially distinct in the past ten years, but as long as they are consistent in operation the periodic terms can be computed.

No assumption of the length of the periods has been made. The tabulated residuals of level corrections give the period and epoch for the first annual term. Applying corrections for the effect of this term, the secondary term, with a period of 1.2 years, was derived from the tabulation of the residuals remaining.

Corrections for the second term were then applied to the original tabulation, and the first annual term was computed anew. This process of approximation is necessary, because the overlapping periods mask to some extent the effect of each, and also because there are gaps in the record of level observations. With an uninterrupted consecutive series of readings, over an interval that includes full revolutions of both terms, the mean results would be nearly independent of the effect of the overlapping periods. An interval of six years includes five revolutions of the secondary term, and any multiple of six years should give a direct means of determining both periodic variations, with the increased precision of the greater amount of material.

In the international series of zenith telescope observations for latitude variation, the desired conditions are amply fulfilled. The long term in $\phi-\phi_0$ has a period of 1.19 years, and 21 revolutions occur in 24.99 years, which is close to commensurability.

The existing material from the level observations of our meridian circle does not entirely fulfill the desired conditions, but satisfactory solutions are obtained by computing each term anew, after applying corrections for the remaining terms. The final computation of the principal annual term gives the following expression for the periodic variation in $b$

$$-0^s.118 \sin (t - 0.04)\ 360^\circ$$

In all these expressions $t$ is reckoned in years and decimals of a year. This periodic variation is probably due to the seasonal changes of temperature, tho the maximum and minimum occur in October and April, with considerable lag behind the periods of highest and lowest temperatures. The probable error of the length of this period is ± 0.0015 yr. or about half a day.

The secondary periodic term is of the following form.

$$-0^s.015 \cos (t - 1894.45)\ 300^\circ$$

The probable error of the length of the period is ± 0.009 yr. or three days.

There is a third term, not as well defined as the first two, possibly because it is of the same length as the most pronounced annual term. As computed from the residual errors remaining after the application of the two other terms, it has the following form.

$$-0^s.005 \cos (t - 1894.2)\ 360^\circ$$

Collecting the three terms, and converting the observed coefficients into seconds of arc, we have the following expressions for the periodic variations.

$$b = -1''.77 \sin (t - 0.04)\ 360^\circ$$
$$\lambda - \lambda_0 = -0''.23 \cos (t - 1894.45)\ 300^\circ - 0''.08 \cos (t - 1894.2)\ 360^\circ$$

Our meridian circle observations of latitude in the interval of 25 years, 1893 to 1918, give the following expression for the latitude variation.

$$\phi - \phi_0 = -0''.14 \cos (t - 1894.27)\, 300^\circ - 0''.11 \cos (t - 1893.82)\, 360^\circ$$

The international series of zenith telescope observations during the past thirty years give the following latitude variation, for the position of the Lick Observatory.

$$\phi - \phi_0 = -0''.16 \cos (t - 1894.33)\, 302^\circ - 0''.08 \cos (t - 1893.84)\, 360^\circ$$

The last expression derived by Dr. Chandler, published in 1894, reduced to the longitude of the Lick Observatory, follows.

$$\phi - \phi_0 = -0''.16 \cos (t - 1894.30)\, 310^\circ - 0''.11 \cos (t - 1893.78)\, 360^\circ$$

The effect of the periodic variation of longitudes would be insensible in meridian circle observations of right ascensions, since the clock corrections are determined with the same level corrections that are used for observations of the stars to be determined. The corrections to the clock at some epochs may be as much as two hundredths of a second in error, as a maximum. In exchanging signals for the differential determination of longitude, the variation would be the same for two stations on the same meridian. Its effect would be small for two stations not far apart, east and west. But for transatlantic exchange of signals, the longitude result might be as much as two hundredths of a second in error, unless allowance were made for the effect of the variation. For two stations on opposite sides of the Earth a maximum error of the double amplitude, or four hundredths of a second, might occur.

July 20, 1921.

# PLANETARY PHENOMENA FOR SEPTEMBER AND OCTOBER, 1921.

MALCOLM MCNEILL

PHASES OF THE MOON, PACIFIC TIME

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|---|---|---|---|---|---|---|---|
| New Moon...... | Sept. 1, | $7^h33^m$ | P.M. | New Moon .. | October 1, | $4^h26^m$ | A.M. |
| First Quarter .... | " 8, | 7 30 | P.M. | First Quarter. | " 8, | 12 12 | P.M. |
| Full Moon ...... | " 16, | 11 20 | P.M. | Full Moon ... | " 16, | 3 0 | P.M. |
| Last Quarter .... | " 24, | 1 18 | P.M. | Last Quarter.. | " 23, | 8 31 | P.M. |
| | | | | New Moon... | " 30, | 3 39 | P.M. |

There will be a *Total Eclipse of the Sun* on October 1st, but the line of totality is badly situated for observation running from the